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Income Levels and Transition of Cooking Fuel Among Rural Poor in India

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Abstract

More than two-thirds of the population lives in rural India. Even after six decades of independence and two decades of economic liberalization, it remains the bitter truth. This study assumes greater significance, because, majority of the rural people are still dependent on biomass fuel for cooking. A reduction in this could help India in greatly reducing the indoor as well as environmental pollution levels; thus helping in containing global warming. It would also help in controlling the health hazards caused due to the indoor pollution in the rural economy; which in effect would help the government in reducing the spending on public health. To make this happen, the government should make the distribution system of kerosene and Liquefied Petroleum Gas (LPG), efficient. This study could be useful not only to India, but to many other economies that are on the threshold of transition; where majority of the population, still lives in the rural areas, and are predominantly dependent on agriculture for their livelihood. This study was undertaken with the objective of analyzing the socio-economic conditions of rural poor in India with respect to their primary energy consumption viz. cooking fuel and impact on health. The study conducts a questionnaire based survey on demographic, economic, and perceptible parameters on modern fuel such as kerosene and LPG; using logit model to identifying variables useful for the study.

Key words: Logit model; Kerosene; Liquefied petroleum gas; LPG; Bihar; Orissa; Rural; Rural India; Biomass fuel

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INTRODUCTION

Over the years, many studies have observed that the process of economic development is generally accompanied by a shift within developing country households toward increasing use of modern fuels, and decreasing reliance on biomass, even in the absence of policies explicitly aimed at achieving this outcome. The type of fuels used by a rural household is determined mainly by its socio economic condition. In many developing countries, biomass fuels namely animal dung, crop residues and firewood are used mostly by very poor people in rural area (Kanagawa & Nakata, 2008). The gathering of firewood and other biomass fuel is a strenuous and time consuming task for rural poor. On the other hand firewood collection and consumption are intricately linked to the degradation of natural resource especially the forest, leading to a situation of firewood scarcity. In addition, there are a number of other adverse consequences of forest degradation, including loss of biodiversity, release of carbon dioxide into atmosphere and soil erosion (Heltberg *et al*., 2000). Similarly, burning biomass in open-fire stoves and often with little ventilation, emits smoke containing large quantities of harmful pollutants, with serious health consequences for those exposed, particularly women involved in cooking and young children spending time around their mothers (Kumar *et al*., 2007). Several recent studies have shown strong associations between biomass fuel combustion and increased incidence of chronic bronchitis in women and acute respiratory infections in children. In addition, evidence is now emerging of links with a number of other

conditions, including asthma, tuberculosis, low birth weight, cataracts, and cancer of upper airways (Mathur, 2001). Worldwide, exposure to smoke emissions from the household use of solid fuels is estimated to result in 1.6 million deaths annually (Balakrishnan, 2004).

Historically in India, biomass fuels constitute the predominant sources of energy, especially for cooking. The most important biomass in rural India are firewood, collected from forests, common lands, roadsides, and private fields; crops residues from farm; and dung, gathered from domestic animals. Firewood is used in almost all rural households. Though these traditional fuels are predominant in rural areas, but the pattern of their use is changing (Viswanathan *et al*., 2005). A shift in demand for kerosene, gas and electricity is observed among the better income groups in rural areas. Kerosene and electricity are used as a fuel for domestic lighting (Chaurey & Kandpal, 2009). However, this switch is negligible as compared to the use of traditional fuels, which is predominant across all income groups.

In the past, there have been various attempts by the government to promote cleaner fuels. The standard approach was to change the relative fuel prices by providing subsidies. The approach has not been very successful in bringing energy transitions, especially in the lower income groups. The poor delivery infrastructure; high cost of connection and refilling; and availability of competing fuel choices in the form of fuelwood and other biomass fuels at zero cost remain as obstacles to quick diffusion of modern fuels in the rural household (The Energy and Resources Institute, 2004). As per some estimates, the annual impact of biomass fuel used by households in India is approximately 500,000 deaths and nearly 500 million cases of illness (Von Schrinding *et al*., 2001). The health effects that have been linked to household fuel smoke in developing countries include acute upper and lower respiratory illnesses (which are the leading cause of child mortality under the age of five in India), chronic bronchitis, chronic obstructive pulmonary disease, asthma, cataract (of which India has the highest incidence among women), and tuberculosis.

In India heavy reliance on biomass has raised pressing concerns over the health impacts of indoor air pollution, as well as over environmental consequences such as deforestation and soil erosion. Therefore the objective of this paper is to discuss the factors guiding rural household choices of cooking fuels. This is crucial for policies to combat indoor air pollution and environmental degradation. As there is economic progression in a country, there is likely to be shift towards use of modern fuels. Understanding this "energy transition", as it has come to be called, is therefore of prime importance for designing policy interventions. It is also important for energy planners who must anticipate future demand for different types of fuels, as well as for those concerned with the longer-term environmental consequences of fuels use. Here we undertake the first analysis of a nationally representative survey of rural households in India particularly Orissa and Bihar to describe patterns of rural cooking fuels used, in the context of the conceptual framework of the energy transition. In the next section we describe the dataset. Following that we present a descriptive analysis, focusing on patterns of fuel use; by income, as well as a logit analysis of the determinants of cooking fuels use and the proportion derived from biomass. Finally, we provide a discussion and summarize conclusions.

1. METHODOLOGY FOR SAMPLE SELECTION AND DATA COLLECTION

The data used in this paper was collected from primary sources based on fieldwork conducted during 2001-2002. The study covered two states of India. In the first stage of the multi-stage sampling used, two districts of each state were chosen. The districts were selected through purposive sampling to ensure that these districts were adequately representative of the state with respect to geographical distribution and special conditions of the state, if any. A total of four districts were chosen at the end of the first stage. Four blocks were identified in district in the second stage through circular systematic sampling using Directory of Blocks as the frame of reference. From each of the selected block ten gram panchayats was chosen using convenience sampling. A gram panchayat is the lowest administrative unit in India. In some cases a gram panchayat may consist of only one village, while in other, it may have a number of villages, hamlets or padas. The selection of villages/gram panchayats was done carefully so that these would properly represent the blocks. Individual respondents were the final sampling units. From each of the selected village or gram panchayat, fifteen respondents were selected randomly. Special care was taken to ensure that respondents were covered under Bellow Poverty Line (BPL) category. Finally, the schedule for respondents filled up for each of them. A total of 2400 were covered in the entire study.

2. FUEL USED FOR COOKING IN RURAL AREA OF ORISSA AND BIHAR OF INDIA

As per provisional figures released, about sixty-nine percent of India's population resides in rural India (Census of India, 2001) and it also has a high concentration of people living under abject poverty. Of the total rural population, nearly thirty percent lives below the poverty line (Rao *et al*., 2009). In the rural areas, the households used mainly firewood and chips, dung cake, kerosene and liquefied petroleum gas (LPG) as the sources of energy

for cooking. Among these sources, firewood and chips was used by almost three-fourths of the rural households. However, less than two percent of rural households use kerosene for cooking. The penetration of LPG is very low in rural India; only about six percent of the households use it for cooking purposes. The introduction of LPG leads to corresponding decrease in the consumption of firewood in rural areas reflects the shifts in cooking fuel (NSS, 2000). On the other hand, the use of dung cake decreased slightly at all-India level.

Table 1
Number of Rural Household Using Different Cooking Fuel

Type of fuel	India	Orissa	Bihar
Firewood	88635032	5075904	3633262
Crop residue	18115410	688659	4719333
Dung	17694317	650773	3803959
Coal	1475498	52206	102921
Kerosene	2240227	47398	42110
LPG	7845161	68982	105660
Electricity	173042	37748	10670
Biogas	647927	16845	9606
Any other	1135083	129996	221975
No cooking	309862	14368	10511
Total	138271559	6782879	12660007

Source: Census of India 2001

An analysis of Table 1 reveals that the total number of households residing in rural India was 138.3 million, out of which, the share of Orissa was five percent, and that of Bihar nine percent. In India maximum number (64 percent) of households uses firewood as cooking fuel, followed by crop residue and dung; whereas about six percent each, of all rural household in Orissa and Bihar used LPG. This is far less than the average LPG usage by rural household across India. In Orissa, about 75 percent of rural household used firewood as primary fuel for cooking; followed by crop residue and dung. But, only about 29 percent of the rural household in Bihar used firewood (Table 1). This may be due to their geographical and socioeconomic condition.

Table 2
Number of Respondents Used Fuel For Cooking

Type of fuel	Orissa [a]	Bihar [b]
Firewood, crop residual and dung	981	1002
Kerosene and liquefied petroleum gas	208	184
Total respondents	1200	1200

Source: Field survey conducted in [a]2001 and [b]2002

A total number of 2400 respondents, with 1200 respondents each from states of Orissa and Bihar, spread across 160 Gram Panchayat of four districts were studied. All the respondents belong to the Bellow Poverty Line (BPL) category. From Table 2, it is observed that 83 percent of the respondents exclusively used firewood, crop residue and dung for cooking; and the remaining 17 percent used kerosene, LPG and electricity. The ratio between the traditional biomass fuel and the modern fuel has been the same in both the states. However, there is a significant difference in the usage of biomass fuel, between the states of Orissa and Bihar (Table 1). This may be due to expanse of forest area in Orissa; which constitutes 37.34 percent of the State's geographical area. Similarly, crop residue and dung used in Bihar is 37 and 30 percent respectively, whereas in Orissa it is only 10 percent each. Agriculture and animal husbandry is the primary driver of the Bihar economy. One of the important features observed in rural area is that, the poor households are dependent on locally available biomass resources, because they are collected at zero cost. The importance of income as a factor affecting fuel use is however, apparent even in the case where the switch to modern fuel is not complete. In India, some study found that the most significant factors determining fuel consumption for cooking were income and location, whether rural and urban (Ekholm *et al*., 2010; Gundimeda & Kohlin, 2008; Pachauri & Jiang, 2008).

Table 3 reveals that the average income per annum among the rural poor in Orissa and Bihar is a little over INR 20,000; with Bihar scoring marginally over Orissa. The difference in income levels could also be due to higher average size of family in Bihar. The low income levels of rural households in both the states, could be the main reason for higher dependence on traditional fuels, which is available free of cost.

Table 3
Socioeconomic Characteristics of Orissa and Bihar

Socioeconomic parameters	Orissa [a]	Bihar [b]
Average Annual Income (Rupees)	19882.02	22850.01
Average Annual Expenditure (Rupees)	21379.07	24304.60
Average Household Size (No)	5.45	6.80
Average Earning Household Members (No)	1.24	1.81

Source: Field survey conducted in [a]2001 and [b]2002

3. DEVELOPMENT OF MODEL

For econometric analysis, the authors have adopted probabilistic logit model for fuel choice (Heltberg, 2003). The dependent variable Y can have only binary values, for representing whether the respondent switch to modern cooking fuel i.e. kerosene/gas or not (Onyekuru & Eboh, 2011). Probability of the occurrence of an event is determined by (Stock & Watson, 2005):

$$\Pr ob(Y=1 \mid X_i) = F(\alpha + \beta_i X_i) = \frac{e^{(\alpha+\beta_i X_i)}}{1+e^{(\alpha+\beta_i X_i)}} = \frac{1}{1+e^{-(\alpha+\beta_i X_i)}} \quad (1)$$

Where, F is the cumulative standard logistic distribution function, which has specific functional form, defined in terms of exponential function and X_1, X_2,….., etc., are independent variables.

For the logit model the interpretation of coefficient β_0, β_1, etc., is transparent, considering the log odds ratio. The logit model can be written as:

$$\log_e \left[\frac{\Pr ob(Y_i = 1)}{1 - \Pr ob(Y_i = 1)} \right] = \alpha + \beta_i X_i \quad (2)$$

Table 4
Definition of Variables

Dependent variables		
FUEL		Switch to modern cooking fuel
	=	1, if yes
		0, otherwise
Independent variable		
INCOME and EXP		Yearly Income and Expenditure of the respondent (in INR)
		1: upto 10000
		2: 10001 – 20000
		3: 20001 – 30000
		4: 30001 – 40000
		5: 40001 – 50000
	=	6: 50001 – 60000
		7: 60001 – 70000
		8: 70001 – 80000
		9: 80001 – 90000
		10: 90001 – 100000
		11: Above 100000
MARKET		Access to Market (in Kilometer)
		1: upto 2
		2: 2.1 – 4
		3: 4.1 – 6
		4: 6.1 – 8
		5: 8.1 – 10
	=	6: 10.1 – 12
		7: 12.1 – 14
		8: 14.1 – 16
		9: 16.1 – 18
		10: 18.1 – 20
		11: Above 20

The effect of a unit change in X on the log odds ratio of the event occurring is given by the corresponding β coefficient. Taking the log odds ratio into consideration is very useful since the interpretation of the coefficient is immediate. As logit model is not linear in parameters, they are estimated by using maximum likelihood techniques. The maximum likelihood estimator is consistent and normally distributed in large samples, so that t-statistics and confidence intervals for the coefficients can be constructed in the usual way. Table 4 defines the variables used in the model. The dependent variable FUEL again can take only binary values for Y_i, with value 1 representing that the respondent switch to modern fuel for cooking and 0 indicating otherwise.

In the independent variables INCOME and EXP, the respondents are classified into eleven categories, with 1 indicating that the respondent has income or expenditure up to INR 10000 per year; similarly 2, 3, 4, etc. with each representing the respondent household's income or expenditure per year pertaining to a particular interval. Using this variable, we try to measure the ability of the respondents to switch to the modern cooking fuel, at a given significance level. The switch to modern fuel has been made, in part, a function of income; because of the fact that we are dealing with spending on modern fuel which increases the household cost; and that the capacity to spend has direct relationship with income (Mishra, 2008). Further, it is hypothesized that persons with larger income will expense more, ceteris paribus. Next variable MARKET represents the distance of the respondent household from the nearest market place, where the modern fuel is available (Arntzen & Kgathi, 1984).

4. ANALYSIS OF MODEL OUTPUT

Table 5 presents the parameter estimates of the logit regression of the binary dependent variable (FUEL) for a selection of three independent variables as detailed above. The estimation, using the SPSS software package, was performed on the dataset consisting of 2400 observations (respondents). Data set from 58 observations could not be used because of some missing data. Thus only 2342 observations were considered for the purpose of analysis.

Table 5
Logit Estimates of Respondents Switch to Modern Fuel on Selected Variables

Variable	Coefficient estimate
Constant	-1.63* (0.17)
INCOME	0.26** (0.12)
EXP	0.23** (0.12)
MARKET	-0.683* (0.07)
Total number of observation (A)	2400
Number of rejected because of mission data	58
Number of cases included in the analysis (B)	2342
Percentage B/A	97.60
Log likelihood for logit	1763.55
Chi square value	332.88

Note: Standard errors are in the parenthesis
** Significance at 1 percent level, and
* Significance at 5 percent level

The estimated coefficients of the independent variable INCOME of the respondent households is positive and strongly significant, implying that with everything else held constant, the respondent having higher income, is more likely to switch over to modern fuel (Gupta & Ravindranath, 1997; Peng *et al*., 2010). This is a very significant finding of this study. The reason could be that the households having more income are probably economically stronger than those having lesser income. Therefore, these households have financial resources to pay for purchasing cooking fuel. This is found to have significant relationship with the switching decision of the respondent. Another motivating factor for the relatively affluent families to switchover to modern fuel could be that it enhances their social status in the local community. The variable MARKET exhibits a negative and high level of significance on switching decision of the respondent. It means that the proximity of the MARKET and accessibility of the commercial fuel, by the respondent household, also play a significant role in the switchover decision. Other things being equal a respondent is more likely to adopt modern fuel, if the MARKET is close-by to the residence of the respondent (Jiang & Brain, 2004; Njong & Johannos, 2011).

$$\Pr ob(FUEL = 1 \mid INCOME, EXP, MARKET) = \frac{1}{1 + e^{-(-1.63 + 0.26 INCOME + 0.23 EXP - 0.68 MARKET)}} \quad (3)$$

Using the above model, five different scenarios are constructed and the probability of switching to modern fuel, under these five scenarios, are computed and shown in Table 6.

Table 6
Probability of Switching over to Modern Fuel in Different Scenarios

Scenario	Income (Rupees)	Expenditure (Rupees)	Market (Kilometers)	Switch to Modern Fuel (Probability)
One	80001-90000	70001-80000	12.1-14	0.1
Two	60001-70000	60001-70000	0-2	0.75
Three	50001-60000	50001-60000	2.1-4	0.50
Four	30001-40000	30001-40000	6.1-8	0.08
Five	20001-30000	30001-40000	2.1-4	0.17

A look at scenario one reveals that even if the respondent household has a good family income, as the when household expenditure is also fairly high, the household is less likely to switchover, if the market is at far away distance from her residence. In scenario two, under similar conditions as that of scenario one, except that when the respondent's residence is at a close proximity to the market, the switchover possibility to the modern fuel increases dramatically to seventy-five percent. Scenario three explains that even a household with moderate income levels has a fifty-fifty chance of switchover, if the market where modern fuel is available is not far off. These two scenarios seem to be the best case for adoption of modern fuel. However, the chance of switchover diminishes drastically, in scenarios four and five, where the respondents belong to poor income and expenditure group. In the last two cases, irrespective of market accessibility the switchover probabilities are very less. From the analysis of the five scenarios given above, it can be observed that INCOME and the level of EXP has positive impact; whereas MARKET has a negative impact in determining the likelihood of switching over to modern fuel. However, non-availability of modern fuel seems to be the major detrimental factor, in the switchover decision. However, income and expenditure have positive impact in moving towards modern fuel. Hence, the families having relatively higher income and household expenditure; and living close to the market, have a very high probability of adopting modern fuel as the cooking medium, than the families living far away from the market.

CONCLUSION

Hike in the modern fuel prices has impacted the pockets of rich and poor equally. The cooking cost of the middle income group is pinching his pockets; and the increase in household budget is threatening even the mere existence of the poor man. Besides, there is also a constant concern over the environmental impact and global warming. According to some of the existing studies, the biomass fuels for cooking are the major indoor air polluters in the world today. In the prevailing circumstances, it becomes essential to look for modern fuel for cooking by the poor rural household. The most significant step towards reducing biomass fuel consumption could be by adopting liquefied petroleum gas. This enables reduction in indoor air pollution and saves forests.

Data collected through the field study and subsequent data analysis, revealed that there is a reasonable amount of awareness and acceptability of modern fuel by the rural poor in India. About sixteen percent of the poor household respondents that took the survey have kept kerosene and LPG as an additional fuel for cooking, which is a very less proportion, considering the lack presence and penetration of modern fuel in rural India. The factors emerging out of the analysis is that the income of the respondent has

great influence in the switchover to modern cooking fuel; but, the easy availability has even greater importance. The study further reveals that the economically better off respondents are prepared to switchover to modern fuel provided the availability of the fuel is made easier. The biomass fuel is available free of cost, as it can be collected from the nearby forest land. Besides, the rural households are primarily dependent on agricultural income for their livelihood. Most households are gainfully employed only at the time of cultivation; thus have much free time during off-seasons. Hence, they can productively use this free-time for collecting the firewood and other biomass fuels. So the motivation for the switchover to modern fuel, especially among the rural poor is far less; and given the fact that major portion of their monthly income is spent on food items and other daily needs. As regards the affluent rural households, the use of modern cooking fuel over traditional fuel seems to be more of a social need, rather than choice. It enables them to be set apart from the local masses. Use of modern cooking fuel seems to enhance their social status amongst other rural households, especially within the village. The proximity of the household to the market seems to the predominant factor in determining the switchover to modern fuel, than the household income or its monthly expenditure.

Promoting the use of modern fuel could also act as a great boost to an emerging economy such as India because, at every world forum, environmental concerns form part of core discussions; and voices on air pollution are raised. Immense pressure is mounted on India and other emerging economies to have control over air pollution. Making the modern fuel easily available will be beneficial, not only for the development and industrialization, but will also help in containing environmental pollution. Government of India should actively consider providing incentives, duty cuts, etc., and encourage supplying improved fuel for cooking to the rural poor. This ultimately achieves dual purpose of bringing down air pollution levels, as well as helping the rural poor in embracing modern fuel. By adopting cleaner fuel, government will be in a position to reduce the rural health hazards, which would ultimately help in reducing the government spending on public health; as also improving the living conditions of the rural poor. This would result in a win-win situation, both at the micro as well as macro levels. Hence, the onus is on the government to promote the use of modern fuel in the rural economy by making it easily available as well as provide monetary incentives/subsidies to the rural poor for adopting modern fuel.

This study is undertaken with the objective of analyzing the socio-economic conditions of rural poor in India with respect to their primary energy consumption viz. cooking fuel and impact on health. The study conducts a questionnaire based survey on demographic, economic, and perceptible parameters on modern fuel such as kerosene and LPG; using logit model to identifying variables useful for the study. More than two-thirds of its population lives in rural India; and even after six decades of independence and two decades of economic liberalization, this remains the bitter truth. This study assumes greater significance, because, majority of the rural people are still dependent on biomass fuel for cooking. To make this happen, the government should have an efficient distribution system for of kerosene and LPG. This study could be useful not only to India, but to many other economies that are on the threshold of transition; where majority of its population is still living in the rural areas, and are predominantly dependent on agriculture for their livelihood.

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